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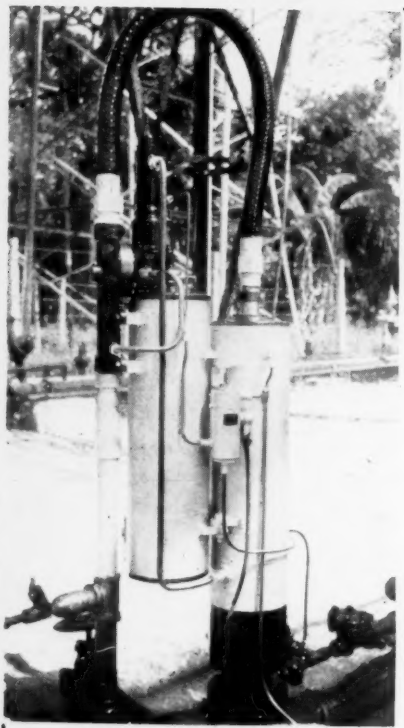

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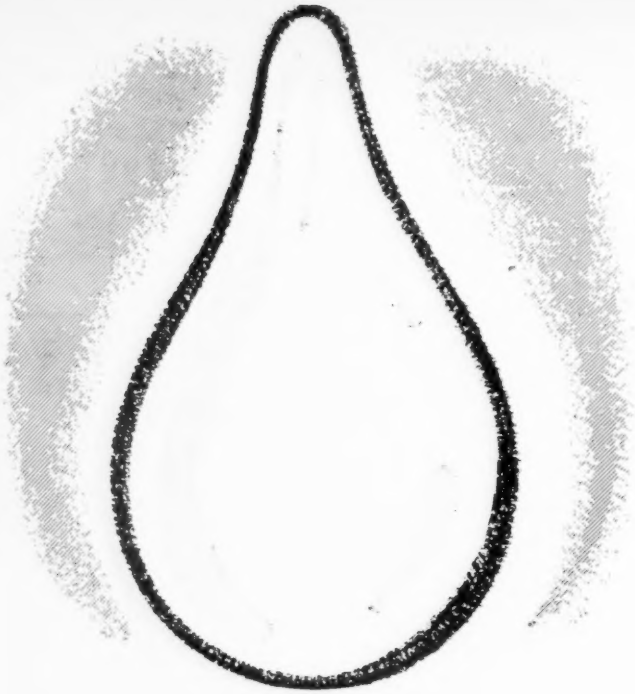

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PETROL INJECTION APPLIED TO SPARK IGNITION ENGINES

By D. DOWNS AND V. H. ROBINSON

INTRODUCTION

SINCE the early days of the petrol engine the normal method of metering the fuel and mixing it with the air in the correct proportion has been through the medium of a carburettor, a simple form of which is shown in Fig. 1. The depression produced in the throat of the venturi or choke tube by the flow of intake air causes fuel to pass into the air stream via the jet at a fairly high velocity, thus producing a fair degree of atomization. The process of vaporizing and mixing continues in the induction manifold downstream of the carburettor resulting, under ideal conditions, in a homogeneous mixture being aspirated into the engine cylinder. The variation of the pressure in the venturi with air flow is utilized to meter the fuel in correct proportion with the air under all engine operating conditions.

The carburettor in its original form had the advantages of being simple in construction and cheap to make, and generally speaking, its performance was satisfactory. With the modern carburettor this simplicity has been largely lost, for it has been found by experience that certain special auxiliary devices are desirable to ensure the correct proportioning of the fuel and air under the very varied engine speed and load conditions obtaining with a modern aircraft or road vehicle engine. Thus, some sort of compensating system is generally used to

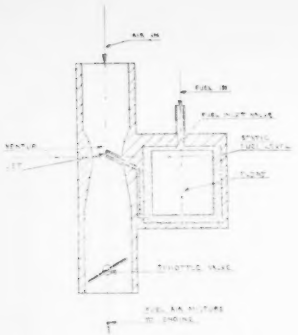

Fig. 1.—Diagram of simple carburettor (not to scale).

overcome the progressive richening of the fuel-air mixture with increase of speed at full throttle which occurs with the simple jet system described above. In most carburettors also, an accelerator pump is used to maintain the correct mixture when the throttle valve is suddenly opened, as this would normally give rise to a momentarily weak mixture due partly to the inertia of the fuel and partly to the suddenly increased pressure in the manifold. With the aircraft carburettor these refinements have gone even further and now include compensating devices for boost pressure, inlet air temperature, etc.

In spite of its almost universal use the carburettor has certain disadvantages which may be summarized as follows:

1. The choke tube which is necessary not only to meter the fuel but also to cause sufficient atomization, results in a reduction in the volumetric efficiency of the engine and hence the maximum power which may be obtained.

2. The use of one carburettor on a multi-cylinder engine may result in poor distribution of the fuel between cylinders unless a considerable degree of manifold heating is provided to assist the vaporization of the fuel. Such heating naturally involves a further reduction in volumetric efficiency. If an attempt is made to overcome the maldistribution by increasing the number of carburettors, not only does expense increase, but synchronization difficulties may arise.

This maldistribution is, of course, particularly severe in cases where special high-boiling constituents, such as tetraethyl lead or monomethyl aniline, are used.

3. A high degree of scavenge on a supercharged four-stroke engine can have a beneficial effect on volumetric efficiency and also upon knock limited power output, particularly at weak mixtures. However, the wide valve overlap necessary results in a considerable loss of unburnt fuel to the exhaust when a carburettor is used.

4. Owing to the loss of fuel to the exhaust during the scavenging period of a two-stroke, economical operation at high power output is impossible with normal carburation.

5. With a carburettor it is necessary to make provision for a rich fuel-air mixture for starting. Such devices frequently cause a quantity of liquid fuel to settle on the cylinder walls during starting, and this, by washing the lubricating oil off the surface, can give rise to increased cylinder bore wear.

6. Any benefits from "ramming" that might be obtained by tuned induction pipes are very much reduced by the presence of the choke tube and common inlet manifold.

Thus it can be seen that, although the carburettor has adequately served the petrol engine for a long period, it nevertheless has a certain number of inherent limitations which restrict the performance of the engine. Much thought has therefore been given, more particularly in recent times, to some alternative method of introducing the fuel into the engine. Various systems of petrol injection have resulted, of which the following are the three main types:

(*a*) Continuous injection into the induction manifold or into the eye of the supercharger impeller.

(*b*) Timed injection into the individual inlet ports.

(*c*) Timed injection directly into each cylinder.

Each of these methods is to a certain degree effective in eliminating the disadvantages of carburation. Thus, most petrol injection systems dispense with a venturi in the inlet manifold, although there are a few instances (in particular the Bendix arrangement fitted to the Wright engine described below) in which such a venturi is used as a part of the automatic mixture control system.

With timed injection to the individual cylinders fuel distribution variation can be made small. Not only does this result in improved economy, because it is possible to operate with an overall weaker mixture, but also the bad effects of maldistribution of the lead are eliminated. With this arrangement also, auxiliary devices to aid cold starting, acceleration, etc., are not necessary as the fuel is placed directly where it is required and so does not have to pass in vapour form through the inlet manifold.

A timed petrol injection system has made possible the development of a high-speed two-stroke petrol engine with a minimum fuel consumption at least as low as that of a comparable four-stroke unit. This is because the introduction of the fuel can be controlled to such an extent that only under the most adverse conditions is any fuel lost to the exhaust during the scavenging period. Thus, a Ricardo experimental two-stroke engine of 4·81-inch bore and 5·5-inch stroke has been developed to give 204 p.s.i. b.m.p. with a gross fuel consumption of 0·42 lb/b.h.p/hr. With water-methanol injection 354 p.s.i. b.m.p. at 4000 r.p.m. (219 b.h.p/litre of engine capacity) may be obtained.

At the present state of design and manufacture the major point that any timed injection system has to concede to the established carburettor is on the score of cost. This is due not so much to complexity of design in the injection system as to the very close tolerances in manufacture which are at present essential in order accurately to deal with the very small quantities of fuel involved. For this reason and others beside, it was natural that the first commercially used engine equipped with petrol injection should be an aircraft engine.

Petrol Injection Applied to Military Aircraft Engines

During the recent war there was a certain amount of controversy as to whether timed petrol injection (as favoured by the German designers) was an advantage in high-output engines for military aircraft. In British military aero engines where the primary requirement was for the greatest power output with the least weight and frontal area, relatively small capacity engines highly boosted, frequently by two-stage superchargers equipped with intercooling were used. Under these conditions continuous injection into the eye of the supercharger impeller is very effective in cooling the charge and lowering the value of the index of compression, thus reducing the power required to give the necessary boost. It was therefore considered unnecessary to evolve and manufacture a timed injection system. This decision was strengthened by the lack of spare production capacity required for such an accurately built instrument as the injection pump to be manufactured in large quantities.

It later appeared that the German engineers concerned did not adopt the petrol injection system for aircraft as a result of comparative tests with efficient carburettors. At the commencement of the expansion of the German air force their carburettor development was lagging, but they possessed considerable

fuel injection experience in the application and manufacture of the Bosch system used on diesel engines. It is therefore not surprising that they intensively developed a petrol injection system at an early stage, and arranged their manufacturing capacity accordingly.

Civil Aircraft

Operating requirements for civil aero engines are radically different. Here the primary consideration above all others should be safety, and it is in this connexion that a timed petrol injection system shows greatest advantage. The safety factor is increased in three ways:

1. By reducing the backfire hazard due to elimination of combustible mixture in the induction system.

2. By minimizing the likelihood of ice formation in the induction system. This is effected by removing the region of fuel evaporation to a point where the fuel can receive the necessary heat without reducing the surrounding temperature to a critically low level.

3. By providing rapid control response which would be invaluable in an emergency; for instance, a misjudged landing attempt. This is because the fuel is placed in or close to each cylinder, and hence a sudden increase in manifold pressure will not interrupt fuel delivery.

The Wright Cyclone Engine

At the time of writing, the Wright Cyclone R-3350 series 18BD is the only aero engine being produced on a large scale commercially, fitted with a timed petrol injection system.[1] This engine has already been flown in service by civil airline operators for many thousands of hours and for this reason the Bendix Stromberg system used will be described here, although it is not necessarily typical. The engine is the civil version of the unit which powered the Boeing B-29 Superfortress during the latter part of the war.

Basically, the R-3350 is an 18-cylinder two-row radial air-cooled engine with a single-stage two-speed supercharger. It has a bore of $6\frac{1}{4}$ inch, a stroke of $6\frac{5}{16}$ inch and a compression ratio of 6·5.

Description of Injection System. The schematic layout of the three principal components is shown in Fig. 2. These are:

(*a*) *The injection pump which divides the metered fuel equally among the cylinders and delivers each portion at the correct point in the cycle and at a suitable pressure.*

(*b*) *The nozzle through which the fuel sprays direct into the combustion chamber in a finely atomized condition.*

(*c*) *The control unit which meters the fuel to be passed on to the injection pump according to the quantity of air being consumed by the engine.*

1. *The Injection Pump.* Broadly speaking, there are two main types of positive displacement injection pump at present available, the fixed-stroke and the variable-stroke types. In both cases it is usual for each engine cylinder to have a corresponding pump element consisting of a barrel and plunger. In the former case the pump plungers are actuated by a cam or swash plate, and the fuel output is controlled by varying the effective length of the stroke, for instance, by altering the point at which a spill valve

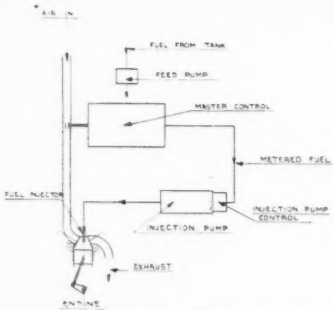

Fig. 2.—Schematic layout of Cyclone fuel injection system.

closes. In the latter case a swash plate of variable angle operates the plungers, and by this means the length of the actual stroke and therefore the output is controlled.

The R-3350 is fitted with two nine-element swash plate injection pumps of the fixed-stroke type. The pump is cylindrical in shape with the pump elements ranged axially round the circumference, the swash plate and tappet followers at one end with the pump output control diaphragms at the other.

The pump plungers are driven up by tappets following the swash plate and are returned by spring pressure, so that if any plunger seizes it will not effect the output of the rest of the pump. The pump delivery is controlled by means of a movable sleeve in which the upper end of the pump plunger works. The position of this sleeve determines the point in the plunger stroke at which the injection of fuel commences.

The injection pump is required to pass exactly the amount of fuel (already metered) which flows direct from the master control unit (described below). This is arranged by having the movable sleeves connected by a common rod to two diaphragms of different size (see Fig. 3). The diaphragms are in a common chamber, full of fuel at the line pressure, and the space between the two diaphragms contains air at the venturi pressure.

Thus, owing to the difference in size between the diaphragms, any increase in fuel line pressure due to increased flow from the master control unit will move the rod, and therefore the plunger sleeves, against control springs which are provided. This will increase the injection pump output, causing the inlet pressure to drop until a point of equilibrium will be reached when the control spring thrust balances the fuel pressure acting on the diaphragms. A decrease in fuel line pressure will, of course, have the opposite effect, the force required to move the sleeves being provided by the control springs.

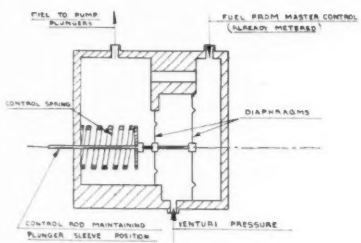

Fig. 3.—Simplified diagram of Cyclone injection pump control unit.

The outputs of the two nine-element pumps are mechanically synchronized for better accuracy.

2. *The Nozzle.* This is of the poppet valve type, opening into the combustion chamber by fuel pressure working against a spring. The cone-shaped valve (the spray cone produced has a 30° included angle) is machined at the end of a central stem. The nozzle is placed at the top of the cylinder with the spray clearing the plugs placed on either side. In order to avoid fouling the plugs, it is most important to maintain a perfect cone-shaped spray at all valve openings, and therefore the stem must remain absolutely concentric. For this reason the fuel is carried down the nozzle in a spiral groove machined in the central stem, this arrangement giving a greater cylindrical surface-bearing area than other methods. On this engine, therefore, the spiral groove is not used in order to impart a swirl in the fuel at exit, as is sometimes supposed.

3. *The Master Control Unit* (Fig. 4). This consists of two diaphragms in separate chambers connected together axially by a rod which directly actuates the inlet fuel control valve. One side of the first diaphragm is sensitive to venturi pressure (below atmospheric) and the other to the velocity of the air in the induction manifold (this air circuit is subject to pressure correction by an aneroid bellows directly connected and

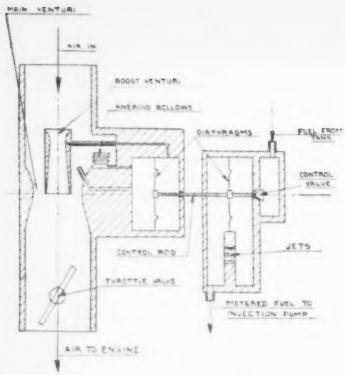

Fig. 4.—Simplified diagram of Cyclone master control unit.

located in the air stream). Thus movement of this diaphragm is controlled by the mass air flow. The second diaphragm is sensitive to fuel flow as the pressure across the diaphragm is the pressure across a system of metering orifices through which the fuel passes from the tank to the injection pump. Thus the air and fuel diaphragms both have differential pressures which under equilibrium conditions balance each other. Any change in mass air flow puts the air diaphragm out of balance, and the fuel control valve operates to change the fuel flow to maintain the predetermined proportions.

Fuel vapour eliminators, consisting of a simple float and valve which vents air or vapour in the fuel, are fitted both upstream of the fuel inlet valve to the master control unit, and close to the control diaphragms on the injection pump. These are very important in a petrol injection system as gas present in the injection pump will interfere with the correct metering of the fuel.

Performance of the Bendix Injection System

The Wright R-3350 engine is especially suitable for the direct injection of the fuel into the cylinder as the intake air is admitted almost tangentially to the cylinder, and the fuel is directed towards the oncoming air. In this way the break-up of the fuel spray is facilitated and the proper mixing of the fuel and air is ensured.

It is claimed that the injection system is capable of functioning for as long as 600 hrs between overhauls. The maintenance of the equipment does, of course, demand skilled personnel and suitable facilities but this should not present any difficulties to a well-equipped airline.

Although it is primarily the elimination of the backfire hazard which has made direct injection a requirement for some American commercial aircraft, it has been found in practice that a fuel saving of some 2 to 3 per cent has also been obtained. This is equivalent to an increase in payload of 200 to 300 lb on a four-engined aircraft operating on a transatlantic service.

Petrol Injection for Road Vehicle Engines

For a variety of reasons, mainly economic, the application of petrol injection to the road vehicle engine has not proceeded so far as it has in the case of the aircraft engine. There are, however, quite a number of directions in which a petrol injection system would appear to be beneficial for automobile engines:

1. Improved fuel and lead distribution. The former would enable an overall weaker mixture to be used, giving increased economy. The latter is becoming increasingly important, owing to the present-day difficulty in obtaining a good grade base fuel, which increases the probability of a high lead content being used in the future. It has been shown that with a normal carburettor lead distribution variation is many times greater than that of the fuel. With an injection system the distribution

variation of lead and fuel would be about equal and greatly reduced.

2. Excellent cold-starting characteristics obtainable without saturating the engine with fuel, thus eliminating one of the major causes of cylinder bore wear.

3. Improved economy. It should be possible to effect control of the engine over part of the power output range by alteration of mixture strength while keeping the throttle fully open, e.g., qualitative rather than quantitative control. This is especially true if advantage is taken of the charge stratification possible with a specially designed combustion chamber coupled with direct petrol injection into the combustion chamber.

4. Rapid accelerator pedal response.

5. For the high output sports car engine the considerable increase of power obtainable by use of ramming pipes should not be overlooked.

However, the cost of the types of injection systems at present sufficiently developed are prohibitive for all but the most expensive cars. For lorries, this high initial cost does not appear to be so serious a drawback, as over the large mileages covered by these vehicles the gain in overall efficiency possible with petrol injection might show up to considerable commercial advantage, even allowing for the higher initial outlay. Nevertheless, the standard jerk pump system (directly developed from that used in high-speed diesel engines) is by no means the only possibility. If injection was made into the inlet port of each cylinder a nozzle opening pressure of 50 to 100 p.s.i. might be sufficient, and so would make possible the use of a pressure rail system employing a continuous flow pump (probably of gear type) supplying a distributor unit at constant pressure. Such a system should be cheaper to manufacture than the conventional jerk-pump system.

Another potential drawback to the application of petrol injection to a road vehicle engine is the small size of cylinder to be catered for. This indirectly provides atomizing problems, as it is difficult to get the most suitable type of nozzle discharge without the spray hitting the combustion chamber walls. With port injection, collision of the spray with the inlet valve does not seem to affect the performance. However, with direct cylinder injection, jet impingement on the cylinder walls would certainly have destructive effects upon the lubricating oil film and would probably reduce performance, as evaporation and mixing would be impaired.

Nevertheless these drawbacks have not prevented Messrs Thornycroft from marketing an efficient petrol injection engine of 7·88 litres capacity developed from their NR6 oil engine.[2] This unit powers the first petrol-injection engined vehicle to be put into production in the U.K., and is at the time of writing still unique in this respect. It is in a way a special case, as it was developed to meet a demand for an engine giving 150 h.p. which could be fitted to an existing chassis. The NR6 oil engine, the largest in the Thornycroft range, would give 100 h.p. and, by comparison with Thornycroft petrol engines, it was calculated that a carburetted version of this engine would still not give 150 h.p. Petrol injection, by enabling the required horse-power to be obtained on an existing size of engine for which standard parts already existed and which would fit into a standard chassis, has enabled considerable savings to be made in manufacture. In other circumstances, the higher cost of the petrol injection engine compared with a similar carburetted engine would probably have decided the issue in favour of the latter. This engine, by demonstrating the practicability of the petrol injection system for road vehicle engines does, however, form a landmark in engine development.

In the Thornycroft, the fuel is not injected directly into the cylinder, but is delivered into the inlet port of each cylinder, just behind the inlet valve, by

means of poppet valve injectors and a slightly modified C.A.V. oil-engine type jerk pump. The fuel is metered in correct proportion to the air under all conditions by driving the pump directly by the engine and controlling the effective stroke of the pump at each speed in accordance with the variation in induction manifold depression.

Conclusions

It seems probable that in the future an increasing number of civil aircraft engines will be fitted with some system of timed petrol injection, as apart from any possible gains of power and efficiency the resulting increase in safety makes it an attractive proposition

The case of the road vehicle engine is rather different because here the economic factor is of primary importance. There seems little doubt that unless a big gain in efficiency can be demonstrated, say, by use of a stratified charge, widespread application of petrol injection will have to await the development of a cheap and simple injection pump. A considerable amount of development work is being done along these lines both in the U.K. and abroad, and it is probable that before long a simpler injection system will be developed which will enable the advantages of direct petrol injection to be obtained at a much lower cost than is at present possible.

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OIL FOR THE BERLIN AIRLIFT

During the period of the Berlin airlift a total of 27½ million gallons of oil supplies were received at the three airfields in the Berlin area. Of this total, about 14 million gallons were handled at Gatow alone.

The fuelling of the aircraft at the dispatching centre—Hamburg—was undertaken by the Shell organization, which was also responsible for the unloading and distribution of cargoes at Gatow airfield. It is of interest to note that a 3-km pipeline from the airfield to the loading wharf on the Havel was constructed from pipes recovered from PLUTO.

The two photographs below show (*left*) a cargo of M.T. spirit being transferred from the railcar which brought it from the docks into the road tanker which took it to the aircraft at Fuhlsbüttel airport, Hamburg. On the right the converted Lancaster bomber *Jig Uncle* is being loaded with the 6000th cargo —6½ tons of M.T. spirit—and refuelled from the unit on the left of the picture.

REVIEW OF DRILLING AND PRODUCTION IN GERMANY 1948

By LUDWIG HAPPEL*

General Introduction

Drilling and production records showed an increase of 51·48 and 10·34 per cent respectively, compared with 1947. This was partly due to the effect of the currency reform introduced in Western Germany on June 20, 1948. Up to that date operators had readily appropriated cheap Reichsmarks for exploration instead of paying excess profit taxes, but efficiency was low on account of out-dated equipment and the low morale of labour. Since June 1948 conditions have improved palpably. Through the channels of the Marshall Plan the German oil industry tried to catch up with the enormous technical progress in the outside world. Control by Military Government tended to be less rigid and in 1949 turned to advice, leaving more freedom of action to the operators. Prices for crude oil were fixed at DM 165 per ton for top quality, an increase up to 37 per cent to compensate for higher prices of equipment and higher wages. Producing companies, anticipating that competition against imported oil may become severe, made attempts to cut down exploration and exploitation costs by speeding up efficiency.

EXPLORATION

Geophysical Operations

No. of geophysical crew months:

Seismic reflection	*146*
Seismic refraction	*11*
Gravity meter	*21*
Torsion balance	*5*

Fresh impetus was given to seismic reflection work by the importation of three modern American units, two of which had been ordered by the Oil Branch, Fuel and Power Division of Military Government, to carry out a long-range programme. The third American reflection outfit was brought in by the parent companies of Brigitta (BPM and Standard Oil Co. of New Jersey). Besides the American units two outfits of German design were put in operation. The centre of reflection activity was the Emsland. Other areas under investigation were the Münster Basin (Carboniferous prospects), Oldenburg, Schleswig-Holstein, and various salt dome flanks in the areas between salt domes in the Hannover district.

Refraction shooting was carried out for a short reconnaissance survey in the Molasse Basin in Bavaria. Gravity surveys were used on a limited scale only.

Core Hole Drilling

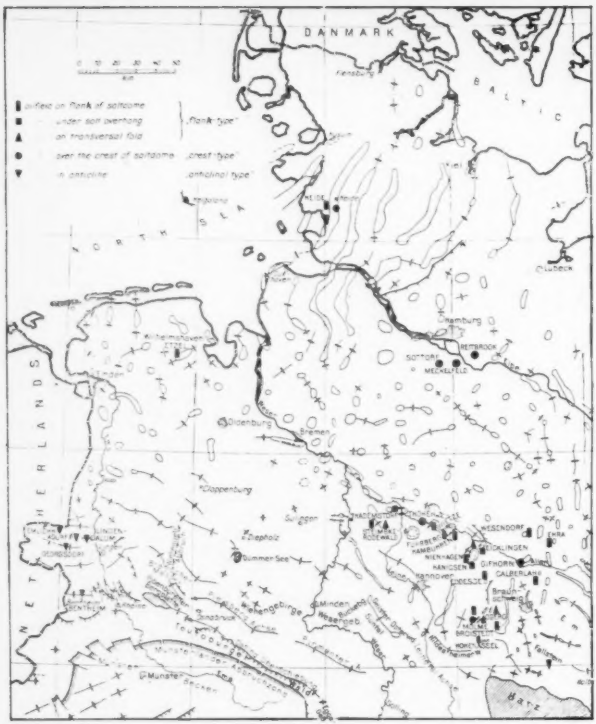
The use of core hole drilling has considerably expanded. In north-west Germany 34 prospects were under investigation, ranging from Emsland, southern Oldenburg, Schleswig-Holstein, to southern Hannover. In Bavaria two parties (Brigitta-Elwerath-Wintershall groups and BMI) were engaged in searching for shallow indications of deep fault zones.

Surface mapping was carried out in the western part of the Molasse Basin by Wintershall in preparation for core hole drilling.

In total, 28,993 m of core holes were drilled in 1948 (10,416 m in 1947).

Core hole drilling on top of the Wesendorf salt dome added a third

* Shell Petroleum Company: geologist with Gewerkschaft Brigitta, Steimbke Krs. Nienburg/Weser, Germany. The assistance of the Reichsamt für Bodenforschung and of geologists of German oil companies in furnishing data is gratefully acknowledged.



North-west German oil basin.
(Reichsamt für Bodenforschung, Celle)

horizon to the existing two deeper ones, when core hole No. 1002 was completed as a producer (1 ton a day) in basal Lower Cretaceous by the Elwerath-DEA-Preussag group. Gas shows were met in Wealden beds at the Rautenberg anticline by Elwerath. The broad shallow structure between the Sarstedt-Sehnde and the Mölme-Gross-Ilsede salt domes may carry a stratigraphic trap of Wealden beds overlapped by transgressing Valendis.

Exploration Wells completed during 1948

Wild-catting in the Emsland, where east-west running folds complicated by faulting provide favourable traps, was not too successful in 1948.

Rühlertwist No. 1 (Wintershall) was located on the eastern extension of the Coevorden-Schoonebeek axis. Valendis sand was found too deep to be oil-bearing. The search for structurally higher positions will be continued. The Itterbeck structure is still waiting for a Zechstein deep test. German operators were reluctant to bring in heavy equipment as long as the Dutch claim on frontier corrections remained unsettled. Meanwhile, the testing of Lower Cretaceous sands in C. Deilmann's Itterbeck No. 4 had negative results. Though Deilmann-Elwerath's Norddeutschland No. 3 and Salzbergen No. 1 on the Bentheim axis found the Zechstein Platten-Dolomit to be watered, drilling was continued by two outposts (Schüttorf No. 1 and Salzbergen No. 2).

Oldenburg (Brigitta-Vacuum) was the scene of an active campaign which included regional seismic reflection, a gravity survey, and core hole drilling. Results of deep drilling on top of the broad interdomal structure of Dangast

outlined by seismic reflection were disappointing. Instead of a complete sequence the well encountered the same formational gaps (Lower Cretaceous transgressing upon Liassic), which are a common feature on many north-west German salt dome flanks. In the Dangast No. 1 bore hole all possible reservoir rocks had been eroded. Continuing drilling around the Zwischenahn salt dome, well No. 5 struck again a porous sandstone in Valendis which had first been met in No. 3. However, the great depth at which the Valendis sandstone was found (1680–1717 m) below the salt overhang proved to be prohibitive. It is assumed that the Valendis will rise to a higher position on the flank of an interdomal structure north-west of Zwischenahn salt dome. This type of structure will possibly attract more attention in the future.

In the Hamburg and the Hannover areas a number of salt dome flanks were drilled without encouraging results. Although locations had been chosen far down-flank, there were still considerable breaks in the stratigraphical sequence, cutting out potential reservoir rocks. In the Hannover district two interdomal structures, Stöckendrebber and Suderbruch, outlined by seismic reflection, were drilled by Brigitta and Socony-Vacuum. Stöckendrebber proved to be dry down to Uppermost Jurassic. Suderbruch No. 1 carried shows of light oil in Upper Jurassic limestone which will be tested in 1949. Further evidence that salt domes may rise from areas of pronounced subsidence was given by Hope No. 1 (DEA-Brigitta-Vacuum), which was abandoned at 1979 m still in Albian beds. Koller's Celle No. 3 was a deep flank test with interesting oil shows in Upper Dogger at 1625 m, which may lead to more successful drilling higher up. The only successful wild cat completed in 1948 was Elwerath's Stemmerberg No. 4 with 1 cu. m. a day from Cornbrash (Upper Dogger). The discovery is credited to surface geology. Tectonics are complicated and future development is not very promising.

In the Gifhorn basin several salt dome flanks were drilled without success (Schneflingen, Nettgau, Bodenteich). DEA and Vacuum's Hardesse No. 2, on what seemed to be an interdomal structure west of Gifhorn, carried only slight oil shows. Further drilling will explore the possibility of a stratigraphic trap on the edge of the Gifhorn basin. Although Elwerath's Bodenteich No. 4 missed the Dogger second sandstone either by a fault or by erosion of transgressing Wealden, exploration of this part of the Gifhorn basin and its possible northern extension is considered attractive.

OFFSET WELLS AND NEW HORIZONS

To safeguard a normal development along the Dutch-German border, which runs through the Schoonebeek-Emlichheim field, an agreement on the spacing of offset wells was signed between Neederland'sche Aardolie Mij and Wintershall in March 1948

Emlichheim's Ringe No. 1 was located as an off-set to Schoonebeek No. 45 on the Dutch side, but met top Valendis (at 888 m) rather low. Production rapidly went to water and the well was abandoned. On the Adorf structure, Adorf Nos. 2 and 3 followed up the discovery well. Drilling results showed an intricate pattern of faults in combination with rapid changes of sedimentation, which may have an adverse effect on further development. Lingen No. 29 may extend the Lingen field in a south-western direction for 1300 m; total area is now 300 hectares. Following up the outstanding result of Georgsdorf No. 26, a number of wells were located on the west-plunge of the Georgsdorf axis. Due to thicker and more permeable pay-sand, production per well is higher than in the eastern part of the field.

In Heide (Schleswig-Holstein) semi-exploration was continued to the north

(Hennstedt area), on the barren east flank, and in southern direction, where a small production could be established by two wells near Marne. Development drilling in this area will result in increasing production in 1949.

In the Hannover district none of seven extension tests was completed successfully. Vacuum-Wintershall's Eilte No. 5, following up the discovery well No. 4, did not encounter any porous Wealden beds. Further drilling activity was suspended. In Rodewald-Steimbke attempts to step up production, from Serpulite horizon in the north field, failed in Brigitta's outsteps WA No. 248 and No. 250. Serpulite was either eroded or dry. In Thören: no oil shows in Wealden and Cornbrash, the Rhetic cut out by a fault, was the result of DEA-Brigitta's Thören No. 68, located on the south flank of the salt core. Deeper prospects in Vacuum's Hänigsen field were not favourably viewed after Siegfried No. 62 had been abandoned as a dry hole.

TABLE I

METREAGE DRILLED IN GERMANY, 1945-8

Year	*Exploitation*	*Extension*	*Wild cat*	*Total*
		Metres		
1945	53,605	7,090	16,426	77,121
1946	46,759	9,737	23,180	79,676
1947	52,448	10,518	42,433	105,399
1948	88,021	22,573	49,110	159,704

TABLE II

NUMBER OF WELLS COMPLETED

Year	*Exploitn*		*Extension*		*Wild cat*		*Total*
	Prod.	*Dry*	*Prod.*	*Dry*	*Prod.*	*Dry*	
1945	70	19	—	—	—	15	104
1946	51	31	2	8	2	18	112
1947	58	18	2	8	1	30	117
1948	94	26	2	17	1	41	181

WELLS DRILLING AT THE END OF 1948

A total of 25 wells were drilling at the end of the year. In the Emsland district Wintershall - DEA - Deilmann's Fehndorf No. 1 penetrated an extraordinary thickness of Upper Cretaceous (about 1200 m). At about 1725 m, Albian was found to overlap Lower Liassic, indicating a Triassic sub-surface high which probably extends into Dutch area. Shore-line sands deposited around this high may provide stratigraphic traps. Hebelermeer No. 1 of Vacuum-Schachtbau-Elwerath was a near miss, showing a loose, fine-grained sand (Valendis) poorly impregnated with dead oil. There is only slight evidence that underlying Wealden shell beds may carry oil. Lingen-Mühlgraben No. 1 of Schachtbau-Vacuum-Elwerath is located south of the oilfield on a separate structure which had been outlined by seismic reflection and core holes.

In Friesland an interdomal structure which is under test east of Barkholt, after drilling on the flank of the salt dome proved unsuccessful. In the Hannover district tectonics around the Blenhorst salt dome are extremely complicated, as shown again by dry hole No. 26 hitting on an overthrust. Elwerath's Hameln No. 2 reached the Middle Zechstein (Upper Permian) at 1906 m, with 6 m of Stink' Schiefer on top, underlain by 11 m of Hauptdolomit. A bailing test revealed that the Hauptdolomit was dry.

DEA's Tölz No. 1 was the only active wild cat in the Bavarian Molasse basin. At the end of 1948 the hole was drilling at 2145 m in Promberg beds of Upper Oligocene. Below an overthrust at 860 m, it penetrated a rather undisturbed but thick section of Miocene Molasse. Showings have not been reported.

About eight extension wells were drilling at the end of 1948. Lingen A 1 will continue to explore the Aptian reservoir after Aptian in Lingen No. 51 has been tested successfully. Kuhlenberg No. 2 is located close to the old tar seepages to find oil below the Nienhagen-Hänigsen salt dome overhang. Potential reservoir beds may extend underneath the 600-m galleries of a potassium mine, calling for careful supervision of drilling operations. To find out possible east-and-west extensions of the Hohenassel field, where pre-Cretaceous faults may have

TABLE III

GERMAN CRUDE OIL PRODUCTION IN TONS, 1945–8

	1945*	1946	1947	1948	*Producing horizons*
		Metric tons			
EMSLAND:					
Adorf	—	—	—	2,163	Wealden
Emlichheim	5,141	24,123	51,996	64,850	Valendis
Georgsdorf	9,269	14,897	24,170	53,096	Valendis
Lingen	16,255	40,709	37,901	47,738	Wealden
	30,665	79,729	114,067	167,847	
FRIESLAND:					
Etzel	1,821	4,719	4,172	4,433	Dogger
HAMBURG:					
Meckelfeld	2,326	2,665	1,940	2,121	Senonian, Lower Cretaceous
Reitbrook	34,471	34,274	34,591	38,443	Senonian, Eocene
	36,797	36,939	36,531	40,564	
SCHLESWIG-HOLSTEIN:					
Heide	90,569	74,364	56,114	50,703	Zechstein, Lower Cretaceous
HANNOVER:					
Broistedt	1,614	2,547	2,862	4,063	Wealden
Eicklingen-Wienhausen	13,530	14,509	13,535	13,044	Wealden, Valendis
Eilte	—	—	86	244	Wealden
Fuhrberg-Hambühren	33,866	51,084	42,437	47,744	Cornbrash (Upper Dogger)
Hademstorf	4,108	6,704	5,684	9,417	Wealden
Haenigsen	35,146	37,553	31,670	32,475	Valendis, Wealden
Hohenassel	31,534	48,642	19,941	18,807	Corallian
Mölme	7,766	7,158	4,929	4,733	Rhetic, Wealden, Corallian
Nienhagen	131,765	129,957	102,833	91,928	Valendis, Wealden, Cornbrash
Oberg	8,265	9,497	5,654	5,681	Dogger, Wealden
Ölheim-Eddesse	2,960	3,014	2,643	2,350	Rhetic
Rodewald-Steimbke	23,572	46,182	41,474	41,550	Cornbrash, Serpulite, Wealden
Stemmerberg	—	—	—	102	Cornbrash
Thören	16,039	19,212	17,225	17,210	Wealden, Rhetic, Cornbrash, Corallian
Wietze	19,931	22,356	21,327	23,055	Wealden, Rhetic, Dogger, Senonian
	330,096	398,415	312,300	312,403	
GIFHORN:					
Calberlah	152	557	395	447	Dogger second
Ehra	44	571	647	612	Dogger second
Gifhorn	1,702	2,129	1,530	1,305	Wealden
Wesendorf	51,418	45,706	44,586	50,886	Dogger, Liassic, Lower Cretaceous
	53,316	48,963	47,158	53,250	
UPPER RHEIN-GRABEN:					
Weingarten	1,204	2,711	2,028	2,080	Oligocene
Forst-Weiher	2,973	4,071	4,247	3,960	Keuper, Oligocene
	4,177	6,782	6,275	6,040	
GRAND TOTAL	547,441	649,711	576,617	635,240	
Daily average	1,500	1,780	1,580	1,740	

* Wells were closed-in on all fields for 2 to 4 weeks on account of the Allied invasion.

	German Gas Production in 1000 cu. m				
Bentheim	71,033	106,372	71,621	60,391	Zechstein
Casing head gas from 8 lesser fields	8,551	8,435	6,070	6,784	
	79,584	114,807	77,691	67,175	

formed separate traps, Elwerath-Preussag and Braunschweigische Bohrgesellschaft's Hohenassel W 1 and Luttrum No. 4 were in progress west of the field. Osterlinde No. 1, east of the Hohenassel field, was a failure.

PRODUCTION

Table III shows the growing importance of the Emsland fields. Their share rose from 5·5 per cent in 1945 to 25 per cent of total German production in 1948. Georgsdorf showed an increase of 113 per cent. The Emsland output in 1949 is estimated at 242,000 tons (one-third of German production). Neither in Georgsdorf nor in Lingen had the edge water line been encountered.

Estimates of proved and probable reserves:

Lingen	1·8 million cu. m.
Emlichheim	2–3 million cu. m.
Georgsdorf	3–4 million cu. m.

The bulk of the Hamburg district's production came from the Reitbrook field where the steep decline curve after 1940 has been flattened by secondary recovery and a small production from Lower Eocene sand. Drilling on Eocene continued at a limited scale. After having tested gas shows in Zechstein (final depth 3053·5 m) with negative result, the deep test T.4 was completed as a producer from Senonian beds.

In the Hannover district the development of the lesser fields was just able to counterbalance the decline of the Nienhagen field (maximum 358,190 tons in 1938). The increase at Hademstorf was due to a higher block, where Upper Wealden with good oil-sands had been preserved. The extension of this block is limited, however. The sharp decrease in Hohenassel in 1947 was due to a heavy drop in bottom hole pressure; wells were choked down and repressuring was started. Wesendorf is the outstanding field of the Gifhorn basin with production found around the dome except the west and north flank. With additional production from Lower Cretaceous on top of the dome, Wesendorf will show a larger output next year. The prospects of the two fields in the Upper Rhein Graben are not encouraging. The productive blocks have been drilled up and estimates on reserves are low.

TABLE IV

PRODUCING FORMATIONS AND THEIR SHARE IN PRODUCTION IN 1948

	per cent
Tertiary	1·52
Cretaceous ..	64·84
Jurassic	29·87
Upper Triassic ..	1·73
Upper Permian ..	2·04
	100·00

Cumulative production of Germany up to the end of 1948 amounted to 12,364,042 tons.

NATURAL GAS PRODUCTION

Bentheim is the only gas field in Germany. Gas is produced by two wells from Upper Zechstein dolomite. The production has been fixed at a rate of 20 million cu. m., corresponding to a drop of the formation pressure for one atmosphere. This production rate amounts to 10 to 15 per cent of the open hole potential. The gas is piped to Chemische Werke at Hüls in the Ruhr area.

Summarizing the position on the German crude oil output, it can be stated that in 1948 the decline in the Hannover, Schleswig-Holstein, and Hamburg districts was more than offset by an increase in the Emsland fields. Although these conditions may continue for a couple of years to come, the discovery of new fields nevertheless becomes imperative to keep the industry going. There is a feeling of cautious optimism among German geologists that they will meet the challenge.

NEW PRESIDENT NOMINATED

The Council of the Institute of Petroleum has nominated C. A. P. Southwell, M.C., B.Sc., as president for the Session 1950–1. Mr Southwell, who is managing director of Kuwait Oil Co. Ltd., and formerly manager of Fields and Geological Branch, Anglo-Iranian Oil Co. Ltd., was elected to the Council of the Institute in 1936 and was made a vice-president in 1949.

Petroleum Technology 1946.—Progress in all branches of the petroleum industry are summarized and over 3000 literature references are given. Published, October 1949, by the Institute of Petroleum. Price 27*s* 6*d*.

PETROLEUM IN PARLIAMENT

Polish Petroleum

In an oral answer on October 24, the Minister of Fuel and Power said that petroleum was not regularly imported from Poland. Small quantities of motor spirit were recently offered for sale and two cargoes were imported into the United Kingdom.

Fawley Refinery

The Minister of Fuel and Power, in a written reply on October 24, said that work on the extensions to the Anglo-American Oil Company's refinery began last May and should be completed in 1952.

Petrol Consumption

In the six months March to August last, civilian consumption of motor spirit in the U.K. amounted to 2,377,000 tons, and consumption by the Fighting Services to 46,000 tons, said the Minister of Fuel and Power in an oral answer on October 31.

Haifa Refinery

The Minister of Fuel and Power was asked on October 31 who owned the pipeline to the Haifa refinery, and to estimate the amount which would have been refined each year and the effect on home supplies had the refinery been in operation.

In a written answer, the Minister said that the pipeline was owned by the Iraq Petroleum Co. The refinery was capable of producing about $3\frac{3}{4}$ million tons of petroleum products a year, of which the American companies had the right to about 25 per cent. The supplies available to British companies would probably have been used to replace purchases of dollar oil rather than to increase the level of home supplies.

The Secretary of State for Foreign Affairs was also asked why supplies of oil had not been obtained by pipeline from Iraq to enable the refinery to operate, and how long the refinery had not been in use.

Mr Mayhew said that the Iraqi authorities had not so far allowed oil to flow down the line to Haifa. The refinery ceased operation on April 1, 1948 and resumed working on October 14, 1949.

U.K. Refining

In reply to questions on crude oil refining in the U.K., the Minister of Fuel and Power, in a written reply on October 31, said that the quantity of oil refined in the U.K. was: 1946, 2·5 million tons; 1947, 2·6 million tons; 1948, 4·5 million tons; and for the first eight months of 1949, 3·9 million tons.

It was not possible to estimate precisely the dollar saving involved, because this depended on the source from which the increases in refined products would otherwise have been obtained. But the gross value in dollars of the increased output expected for the year 1949 over 1946 was about 60 million dollars against which must be set dollar expenditure incurred, for example, on refining equipment. As regards plans for expansion, the Minister had no reason to suppose that the refinery capacity of about 19 million tons approved by O.E.E.C. would not be achieved.

THE ANNUAL DINNER

The Institute's Annual Dinner is being held at the Savoy Hotel on Tuesday, February 28, 1950. Tickets will be £2 2*s*., and full details will be sent to all members, who are requested to note the date.

SIGNIFICANCE AND PROPERTIES OF PETROLEUM PRODUCTS

VI. CLOUD AND POUR POINT

By A. OSBORN (Fellow)

In all phases of their production, refining, distribution, and usage, petroleum products have to be transferred from one place to another. This almost always involves flow through a pipe or tube of some kind; and in this connexion a knowledge of the flow properties of the product is of extreme importance to the designer of equipment. The ability of a product to flow is affected, among other things, by its viscosity and by its liability to change from a liquid to a solid under certain conditions.

It is the main intention in this article to consider some of the factors concerned with the change of certain petroleum products from the liquid to the solid or semi-solid state; and, in particular, to discuss the methods used to determine the property known as "Pour Point", its related property "Cloud Point", and the several associated methods used to evaluate similar properties.

The definition of *Cloud Point* of a petroleum oil is given as "the temperature at which paraffin wax or other solid substances begin to crystallize out or separate from solution when the oil is chilled under prescribed conditions". The *Pour Point* is defined as "the lowest temperature at which the oil will pour or flow when it is chilled without disturbance under prescribed conditions". These two properties are considered together because procedures and apparatus used for their determination are the same.

A full description of the apparatus and procedures employed is given in the I.P. "Standard Methods for Testing Petroleum and Its Products" under Designation I.P. 15/42. This method is identical with the A.S.T.M. method, and has been adopted almost universally throughout the world for the determination of cloud and pour point.

The cloud point of oil is evaluated by chilling it in a glass container under standardized conditions and determining the temperature at which the oil becomes cloudy. Owing to the necessity of observing the first appearance of cloud, the test can be applied only to oils which are transparent. As is indicated in the definition of cloud point, the cloudiness in the oil is caused by the separation of solid substances which may be wax or, in some cases, ice. Sometimes the cloud is due to precipitation of liquid water from solution in the oil. The chief value of the test is to indicate the liability for filters, such as are used in many kinds of equipment, to become choked.

A similar test applied to petrol is known as the "Cold Test of Motor Fuel"; this test is used mainly for aviation fuels, which are liable to be exposed to extremely low temperatures, and from which the separation of solids in filters in the fuel system, or in carburettors, would have most serious consequences.

Another test of the same type is the "Low Temperature Filtration Test", I.P. 85/44, which is used for gas oils and diesel fuels; this test is conducted by first cooling a one-gallon sample of the oil at a suitable temperature for a prolonged period, and then endeavouring to pour the oil through a filter constructed of gauze of a standard mesh. If the oil can be successfully filtered, a further attempt is made with another sample of oil which has been maintained at a lower temperature. This procedure is continued with samples of the oil

which have been cooled at progressively lower temperatures until a point is reached at which the oil cannot be filtered. Alternatively, if the lowest temperature to which the oil is likely to be exposed is known, then a single test may be made on a sample which has been subjected to prolonged cooling at this temperature.

As mentioned previously, the apparatus used in determining pour point is the same as that used for cloud point. The procedure employed, however, differs mainly in that at intervals of 5° F during the cooling procedure the container is tilted for a brief period to ascertain if the oil can thus be caused to flow. At the point when the oil first ceases to flow, the temperature is observed and the pour point is taken as the temperature which is 5° F above this.

Unlike cloud point, which can be used only with transparent oils, the pour point is applied to a wide range of oils, including kerosine, lubricating oil, and fuel oil.

A variation of the pour point procedure which is sometimes used consists in applying pressure to one arm of a U-tube containing the oil under test and determining the lowest temperature to which the oil can be cooled before it fails to flow at a specified rate. One version of the test is known as the "Setting Point", I.P. 54/42. This test can be applied to the same products as the pour point test, and provides an alternative to this test. The results will generally not be the same as for the pour point, but will usually be lower.

Another test of a similar nature is the bottle test, which until recently formed part of the requirement of the Admiralty specification for fuel oil in the clause relating to viscosity. In this test a portion of the fuel is placed in a bottle, which is then packed around with ice in an ice chest and allowed to remain for 16–24 hours. The bottle is inverted, and if the oil flows it is transferred to a viscometer and the viscosity determined; if the oil does not flow, the bottle is well shaken; and if this does not cause the oil to flow uniformly the viscosity cannot be determined and the condition of the oil is reported.

The latest specification for Admiralty fuel oil requires that the viscosity be determined at 120° F, to overcome any difficulties which may arise from the setting of the oil.

One further method used to examine the behaviour of an oil at low temperature is that for determining the channelling characteristics of gear lubricants. This test—CRC Designation L-15-445—which is applied to gear lubricants to determine their suitability for use at a given temperature, consists in cooling the lubricant in a metal container at the specified test temperature for a period of 20 hours, and then drawing a strip of metal through the lubricant in such a way as to expose the bottom of the container. If the lubricant then flows and completely re-covers the bottom of the container in not more than 5 seconds the oil is reported as non-channelling.

In all of the foregoing tests, setting of the oil may be due to two causes; these are:

(*a*) *An increase in the viscosity of the oil through the reduction in temperature.*

(*b*) *Crystallization of wax present in the oil.*

When the setting of the oil is due to the second of these causes alone, the effect of the wax may be likened to that of a sponge, in that the interlocking crystals of wax form a structure, in the interstices of which oil is held in the same way as the sponge holds water. Unlike the sponge, however, the wax structure can be broken down by agitation, such as by stirring or shaking the oil-wax mixture; and the mixture can then readily be caused to flow.

The building up of a crystal structure is affected by the previous treatment

received by the oil; thus, if the oil has been relatively free from disturbance and is very gradually cooled to a low temperature, the wax crystals will be large and will tend to interlock one with another; whereas if the oil has been disturbed a short time before cooling and/or the rate of cooling has been rapid, the crystals found will be small—with less interlocking—and the oil will accordingly not set until a lower temperature is reached. Similarly, if the oil has been heated a short while previous to making the test, it will be possible to cool it to a lower temperature without setting than if it had not been heated. This effect, known as "hysteresis", is, as the name implies, a delayed setting of the oil and is frequently due to the presence of asphaltic and/or resinous matter in the oil-wax mixture. In consequence of this erratic behaviour the procedure to be used in preparing an oil for the pour point test is clearly specified and must be strictly adhered to, as only in this way can reliable results be obtained.

With certain oils, such as cylinder oils and fuel oils, it is customary to determine the "maximum" and "minimum" pour points if the oil has been heated at a temperature above 115° F during the 24 hours preceding the test, or if it is not known whether the oil has been subjected to a higher temperature. The procedure used in making these tests is to determine the pour point in the usual manner, the result being recorded as the maximum pour point, and then to determine the pour point on a portion of the oil which has been heated to a temperature of 220° F; this gives the minimum pour point.

The pour point of a lubricant can often be markedly reduced by the use of "pour point depressants", the addition to a lubricant of as little as 1 per cent of certain of these materials reducing the pour point by as much as 30° F.

Pour point depressants achieve their purpose by forming a coating around the wax crystals, preventing the growth of large wax crystals, and, thus avoiding the building up of a structure in the oil.

It has been found that motor oils containing pour point depressants frequently exhibit "pour reversion" when stored under winter conditions, the oils often becoming solid at temperatures higher than those indicated by their I.P. pour points. Sometimes also these oils remain fluid at temperatures below their I.P. pour points. Investigations have shown that this occurs when the oil is subjected to appreciable temperature fluctuations; and in a test called a "Stable Pour Point Test", designed to study this phenomenon, the oil undergoes exposure to repeated cycles of cooling and warming to determine the highest temperature at which it will become solid. There are several versions of this test, one of which was published by the A.S.T.M. in 1945 as a proposed method for maximum pour point of lubricating oils containing pour point depressants. Up to the present the test has not received the status of a tentative or standard A.S.T.M. method, and the only official version is that for determining stable pour point of diluted S.A.E. 10 oils, published by the Co-ordinating Research Council under Designation L-11-1143.

Some oils, including black oils such as fuel oils, contain so-called natural "pour point depressants", and these oils often behave in a similar manner to the oils to which synthetic "pour point depressants" have been added.

Although a waxy oil may have set, it does not follow that it cannot be caused to flow; and in practice, as previously mentioned, structure can frequently be broken down by stirring the oil, which then reverts to a fluid state. This ability to break down structure is of value in practice, because, if the solidified oil is present or can be introduced into the desired equipment—for example, into a pump—the structure can be broken down and the liquid thus formed caused

to flow in the usual manner, such as by pumping.

In this connexion investigations have shown that, irrespective of its pour point, a crankcase lubricant can be satisfactorily used at a given temperature as long as the extrapolated viscosity at this temperature does not exceed a certain critical value and providing the pump will handle the lubricant. The extrapolated viscosity at a given temperature is the viscosity obtained when the line drawn on a viscosity temperature chart, through two points representing the viscosities of the oil at suitable temperatures, is produced to the desired temperature.

In view of what has been said about the erratic behaviour of wax-containing oils when subjected to reduction in temperature, it may be wondered what value a knowledge of pour point has. The fact is that, in spite of inconsistencies, it does, in the majority of cases, give a useful guide to the lowest temperature to which an oil can be cooled without setting, and it is also a most useful identification test.

Suggestions for Further Reading

In addition to the general test methods given in the standard method books of the Institute of Petroleum and of the A.S.T.M., the following sources of information are useful:

Stable pour point: *Proc. A.S.T.M.*, 1945, **15**, 237, 244.

"Laboratory determined pour points of lubricating oil as related to ability to flow under field storage conditions", J. J. Giammaria: *Bull. A.S.T.M.*, 1946, **138**, 144.

Stable pour point: *C.R.C. Handbook*, 1946, p. 439.

Channelling test: *C.R.C. Handbook*, 1946, p. 452.

"Pour point stability of treated oils under winter storage conditions", C. E. Hodges and A. B. Boehm: *Oil Gas J.*, 24.6.43, **42** (7), 103-6.

"Pour point stability of lubricating oils", L. M. Henderson and W. G. Annable: *Oil Gas J.*, 9.9.43, **42** (18), 54.

"Pour point stability characteristics of winter grade motor oils", J. G. McNab, D. T. Rogers, A. E. Michaels, and C. E. Hodges: *S.A.E. reprint*, 1946.

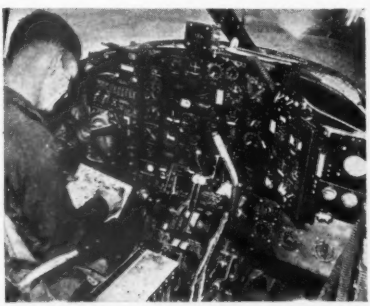
"Some new aspects of pour-depressant treated oils", C. E. Hodges and D. T. Rogers: *Oil Gas J.*, 4.10.47, **46** (22), 89.

JET AIRCRAFT FOR OIL RESEARCH

Shell Oil Co. (U.S.A.) has recently acquired a jet-equipped aircraft for research work. It is a converted B-26 Marauder light bomber with twin piston engines and a turbo-jet engine. Its official designation is XB-26F.

In addition to its role in turbine research, the third engine will be used to boost speed during piston engine research, which will form a substantial part of the programme.

Test equipment will include thermocouples to measure cylinder temperatures, a Sperry engine-analyzer, an oil-flow measuring device, and means of checking blow-by gas in the crankcase. A camera will photograph gauges and dials at regular intervals, and a recording potentiometer will be used for other readings.



The elaborate instruments in the cockpit are for testing fuels and lubricants during flight.
(A Shell Photograph)

COUNCIL COMMENTARY

A RATHER smaller attendance than usual was presided over by H. Hyams after his election to the chair at the Council Meeting on October 12, at Manson House, the president being still in America.

Proceedings began by the general secretary reading a letter from Mr C. A. P. Southwell accepting his nomination for presidentfor 1950–51, the tone of the letter being very much appreciated by the Council members present.

The minutes of the September meeting were then approved and, subject to a correction of wording, items arising from them were dealt with as follows:

In a letter from Mr Cecil W. Wood, appreciating our letter of congratulation sent to him in connexion with the *Petroleum Times Jubilee Number*, we were offered the original year-by-year report of "British Oil Highlights from 1899 to 1949". This offer was gratefully accepted, the documents to be placed in the library in permanent form.

Professor Garner has agreed to be our representative on the National Smoke Abatement Society Advisory Committee.

Reports were received and approved from the Election, House, Publications, and Standardization Committees, miscellaneous matters including a letter from Council expressing pleasure at J. A. Oriel's improved condition, a report from a World Petroleum Congress Committee, various appointments, correspondence, educational courses in the London area, and the results of the ballot for vice-presidents.

Taking the last first, the vice-presidents nominated by Council as a result of ballot were as follows:

M. A. L. Banks.
E. J. Dunstan.
F. Morton.
J. A. Oriel.
J. S. Parker.
H. C. Tett.

In this connexion By-laws Committee were asked to review the particular by-law, the wording of which appeared to cause too frequent retirement by lot!

Certain House Committee recommendations were left over for consultation with the Finance Committee.

The Publications Committee report was presented by E. Thornton in the absence of Prof. F. H. Garner, and dealt with the printing of the *I.P. Review* and what proved to be a very thorny question in connexion with the proposed charge for preprints of papers presented at Ordinary General Meetings. It was eventually agreed to accept the Publications Committee's recommendation that members requiring full sets of preprints to be dispatched to them automatically could have such sets at a charge of 5*s*., but no such sets were to be available for non-members, who could, however, obtain single copies at a price of 1*s*.

The following appointments were approved: A. G. V. Berry as chairman of the Crude Oil Sub-Committee; E. G. Ellis as chairman of Grease Sub-Committee.

T. Dewhurst reported on the work of the British National Committee of the permanent World Petroleum Congress.

In connexion with the proposal for an exhibition of oil equipment in 1951, some concern was expressed at the decision not to proceed with this. The view was expressed that it was very desirable that the oil industry should be represented at the exhibition in 1951 in view of the increasing importance of the petroleum industry in the United Kingdom.

A very appreciative letter, received by E. Thornton from the President of the Institution of Fire Engineers in regard to the recent joint meeting, was read by the general secretary.

The Council endorsed Mr Thornton's action in instructing the general secretary to inform the Regional Advisory Council

for Chemical Engineering in the London area, that in the opinion of the Institute there were insufficient courses available for petroleum and chemical engineering in the London area. As a result, the Institute has been invited to be present at a further meeting of the Chemical Engineering Advisory Council in January next, when the suggestion for devising a common course to suit the intermediate standards of the Institutes of Petroleum, Fuel, and Metallurgy will be discussed.

HAND-FIRED BOILER OPERATIONS

In many works the process is such that steam is best raised in the shell-type boiler. Many are hand-fired and a large number are operated inefficiently for various reasons. In Technical Paper No. 55 of the Fuel Research Station, "The effect of certain factors on the efficiency of a hand-fired, natural-draught, Lancashire boiler" (H.M. Stationery Office, *1s., post 1d.*), the losses due to inefficiency have been assessed. A smoke-eliminating fire door designed at the station is described and trials have shown that smoke can be completely eliminated.

Manchester Oil Refinery (Sales) Ltd. was formed on October 1, 1949, to centralize the U.K. distribution of the products of Manchester Oil Refinery Ltd. previously distributed by Petromor Ltd., Puremor Ltd., and British Transformer Oil & Lubricants Ltd. Overseas distribution will still be handled by Raven Oil Co. Ltd. Details of the new organization are given in a booklet available from Manchester Oil Refinery Ltd., Public Relations Department, 44a Dover Street, London, W.1.

THIS OIL BUSINESS

At their meeting on October 24 the London Branch of the Institute had an interesting talk from P. M. de Veulle (Shell Petroleum Co. Ltd.). The title of the address was "This oil business", and it served as an introduction to a series which will cover various aspects of the industry under the general title of "Petroleum To-day".

In his opening remarks Mr de Veulle pointed out that of the 450 million tons of petroleum now being produced annually, some 150 million tons passed across frontiers in international trade. Of this, about 90 million tons, or 60 per cent, was supplied by American companies, and the balance mainly by British and Dutch concerns. Petroleum was the largest commodity in international trade, in volume and value.

Oil was a wasting asset and thus a capital resource was being used up at a very rapid rate. While there was sufficient oil still below the surface to supply needs for many years, it was necessary to continue and to expand the search for new resources so that future requirements—which were larger year by year—could be satisfied.

The United States was the dominant factor in the petroleum industry, as 85 per cent of the world's oil was supplied by American concerns in the United States and in other countries.

On the question of "dollar" and "sterling" oil, Mr de Veulle pointed out that the designation depended on the nationality of the operating company. Thus in, say, Venezuela, oil produced by an American concern would for currency purposes be regarded as "dollar" oil, while that obtained by a British or Dutch company would be "sterling" oil. The production of "sterling" oil, however, invariably involved the expenditure of dollars or other equivalent hard currency. The "dollar problem" was, therefore, one which vitally affected the whole of the oil industry. As a result,

currency problems rather than economic considerations were tending to become the determining factors in setting the pattern of international trade.

To-day, oil tankers accounted for about 20 per cent of world shipping. Half of the tankers now under construction in the world were being built in British yards.

As an example of the hazards which were inherent to the industry, the speaker pointed out that on an average not more than one well in five drilled for oil was productive. Even then the oil might be poor in quality or small in quantity. The industry made the maximum use of science in all its branches, and in the U.S.A. petroleum research cost no less than $125 million per year.

The products of the petroleum industry were used in some form in almost every branch of economic activity, and it was a striking fact that in most cases those products never saw the light of day. Leaving the well in a pipe, the crude oil and later the products travelled in pipes or closed containers right to the point of consumption.

Capital expenditure connected with petroleum was probably higher than in any other industry. In view of the rapid rate at which the industry was expanding, some sections were considerably affected by the current problems of capital formation and transfer.

Concluding his talk, Mr de Veulle took his audience on a quick survey of the world oil industry. Starting from the U.S.A., where the industry had a highly competitive structure, he travelled via South America to the Far East, where rehabilitation after war devastation was making rapid progress. Then to the Middle East where Kuwait, which began production only three years ago, was now producing at the rate of 12 million tons per annum. A new territory, Qatar, was about to be developed. And so to the U.S.S.R., the only major power other than U.S.A. to be territorially self-sufficient in oil. If the five-year plan has been fulfilled in advance, as its authors hope, the U.S.S.R.'s production this year should be about 35 million tons. Europe, apart from the U.S.S.R., has a few comparatively small producing regions in Roumania, Hungary, Albania, Austria, Poland, Germany, and Holland, the last named particularly important to that country's economy.

At the conclusion Mr de Veulle answered a number of questions, and a hearty vote of thanks was passed to him on the motion of the chairman, seconded by Cecil W. Wood.

"OIL AND PETROLEUM YEAR BOOK"

For the fortieth year in succession Walter E. Skinner has produced his *Oil and Petroleum Year Book*. In its 252 pages of text matter, this 1949 edition gives details of 733 companies engaged in various phases of the petroleum industry. Information is given concerning directors and officers, of capital and dividends, of the nature of the business and, where appropriate, of production and operations. In addition, over 400 names and addresses of managers, engineers, etc., are listed.

Also there are 74 pages of subsidiary matter, of which 32 are devoted to a useful Buyers' Guide, covering a wide range of machinery and materials for the oil industry. A valuable feature of the 14-page index to companies is that it gives back-references to companies which no longer exist, showing the volume of the year book in which they last appeared.

The book is indispensable to those who desire to have readily available particulars of the operations and the structure of the concerns which go to make up the oil industry. Price is 15*s*. (postage 1*s*.), and copies can be ordered from Walter E. Skinner, 20 Copthall Avenue, London, E.C.2.

A NEW EDITION OF "STANDARD METHODS"

Twenty-five years ago the Institute of Petroleum published the first edition of its "Standard Methods for Testing Petroleum and Its Products". This was a modest volume of 102 pages, describing some forty methods of testing petroleum products.

Throughout the intervening years, much work has been carried out on the subject of testing petroleum. In addition, new products have been brought into being and new applications have demanded the formulation of special methods to determine the suitability of these products for specified purposes. Thus the size of this book, the tenth edition of which is just published, has grown to 660 pages of data describing in detail the apparatus for and the procedure of 116 methods for determining physical and chemical properties of crude petroleum and its products. The properties for which tests are available are extremely wide in range, varying from specific gravity to setting-point, from salt content of crude oil to residue on sieving bituminous emulsion.

Compared with the previous (1948) edition, there are numerous changes, and these are listed in the preliminary text of the book. The three new methods are of considerable importance. They are: (1) an engine method of testing heavy-duty lubricants in relation to ring-sticking, wear, and deposit accumulation; (2) a method for research octane number of motor fuels; (3) a method of assessing the corrosive tendencies of cutting oils in contact with cast iron.

Various methods have been revised in detail, including calorific value (now known as heat of combustion), distillation, viscosity, etc., while many editorial amendments have been made to avoid ambiguity.

The price is 31*s.* post free, and copies can be obtained from the offices of the Institute. Members of the Institute can obtain one copy for 26*s.*, post free.

PHOTOGRAPHY IN SCIENCE AND COMMERCE

Some excellent examples of the value of photography in science were shown at the recent 94th Annual Exhibition of the Royal Photographic Society in London and Southport.

Of particular interest was a series showing the break-up of a drop of water in a stream of air. This was taken during a research on the fundamental mechanism of the atomization of liquids by W. R. Lane and John Edwards (*Physics Section, Experimental Station, Porton*), the entire break-up being completed in 6 milliseconds.

Many other examples of the scientific application of photography were exhibited and served to illustrate its increasing importance as a research and industrial tool.

Among the films selected for exhibition was a 16-mm silent film entitled *Crystal Growth*, taken by H. Emmett (*Research Dept., I.C.I. Alkali Ltd.*). This gave an excellent illustration of the layer formation in crystal growth.

Commercial Photography

At the Commerce and Industry Section of the Institute of British Photographers, there were some excellent examples also of the use of photography in commerce and industry. Here we found a fine picture of seas breaking over the bows of a tanker, under the title of *Typhoon*, while *Shell Service—Trinidad* portrayed a kerbside pump with a native attendant. Both were by Derrick V. Knight (*Shell Photographic Unit*). *Drill Rods*, by Michael Ross-Wills, a photograph looking upwards inside a derrick, was also among the many examples of commercial photography.

The Lovibond Comparator is the subject of a leaflet recently issued by and obtainable from The Tintometer Ltd., Milford, Salisbury.

FAWLEY BRANCH INAUGURATED

G. Noble.

THE inaugural meeting of the Fawley Branch of the Institute of Petroleum was held on October 19 at the Esso (Fawley) Recreation Club, Holbury. The chair was taken by G. Noble, refinery manager of the Anglo-American Oil Co.'s Fawley refinery, and over one hundred people were present. These included refinery personnel, representatives of local petroleum interests, and of other organizations.

Prior to the meeting the local Corporate Members of the Institute had elected a committee for the current session. This committee is composed of:

G. Noble (*chairman*).
I. McCallum (*hon. secretary*).
J. R. Baddiley (*hon. treasurer*).
H. Jagger.
F. Mayo.
W. G. Miller.
A. W. Pearce.

Mr Noble expressed his appreciation of the large number of people who had come along to the first meeting. He explained the purposes of the Institute and expressed the hope that as many people as possible would support the newly formed branch by joining as branch members. He felt that the branch would afford valuable contact between refiners, petroleum sales departments, and the users of petroleum products. He said that the branch was planning to arrange a series of lectures throughout the winter period, each lecture being by an expert on a subject of general interest to people in the petroleum industry.

Mr Noble then introduced the lecturer of the evening, Professor F. H. Garner, O.B.E., of the University of Birmingham. He mentioned that Professor Garner was no stranger to Fawley, having been chief chemist to the old Agwi Petroleum Corporation from 1921 to 1928. His wide experience both in the oil industry and in the training of chemical engineers well qualified him to talk on the subject of his address, "The chemical engineer in the petroleum industry".

Professor Garner expressed his appreciation of the honour of being invited to address the inaugural meeting of the Fawley Branch, particularly in view of the fact that his own first industrial experience was gained at Fawley.

Current thought considers the chemical engineer as a modern innovation in the engineering and chemical world, but actually the scope of a chemical engineer had been defined as early as 1901.

The petroleum industry as a whole, including the chemical manufacturing sections, made use of all the various unit operations which formed the basis of chemical engineering. Being a comparatively modern industry, it had been able to adapt to its own purpose much of the equipment which had been developed in other industries. Various examples were mentioned. In the fluid catalytic cracking process, however, the petroleum industry had developed an entirely new method of chemical processing which was now being utilized by other industries. Professor Garner pointed out that in addition to the part the chemical engineer plays in the design of equipment he now has a very important function in connexion with the operation of full-scale equipment in the interests not only of "trouble shooting", but also with the object of developing improvements in the processes. The part played by the chemical engineer in

studying such matters as atmospheric and water pollution were described.

Professor Garner, in his closing remarks, pointed out that the chemical engineer had a part to play in the production side of the petroleum industry and mentioned the treatment of crude oil emulsions and other problems which are met with in the oilfields.

Mr Noble thanked Professor Garner for his most interesting paper, after which Professor Garner answered a number of questions. Some of the questions were of particular local interest because they touched on Professor Garner's early experience with the company and included reference to the Lodge-Tinker cracking process (one of the first cracking processes developed) and the old salt pans which represented one of the early Fawley industries.

THE INTEGRATED OIL BARGE FLEET

At the recent Petroleum Mechanical Engineering Conference of the A.S.M.E. in Oklahoma City, Clancy R. Horton, Jr. (*naval architect for Dravo Corpn*) said that the integrated oil barge fleet can reduce towing costs as much as 25 per cent. The integrated fleet consists of as many as fifteen barges fitted together to form, in effect, a single barge longer than the *Queen Mary* and carrying 155,000 barrels of oil. To get this round bends of radius only two or three times the length of the tow and in currents almost equal to the boat's speed needs atow-boat with maximum steering ability and power. So much progress has been made that these fleets can be easily handled by tow-boats having twin screws and six rudders.

10,024 Feet in 38 Days.—A reprint of the article in *Oil & Gas Journal* (August 18, 1949), describing the drilling of a well to 10,024 ft in 38 days 3 hours drilling time, is available from Oil Well Supply Co.

I.P.C. NEW CHAIRMAN

Admiral Sir J. H. D. Cunningham.

ADMIRAL of the Fleet Sir John Henry Dacres Cunningham, G.C.B., M.V.O., has been elected chairman of the Iraq Petroleum Co. and associated companies. He succeeds Sir Francis Humphrys, G.C.M.G., G.C.V.O., K.B.E., who recently retired after eight years as chairman.

During the course of his distinguished career in the Royal Navy, Sir John early became interested in oil. In the early 'thirties, as a member of the Middle East Sub-committee of the Committee of Imperial Defence, he was in close contact with Middle East oil developments in the period preceding construction of the Iraq-Mediterranean pipelines.

In 1941–2, as Fourth Sea Lord and Chief of Supplies and Transport, he was a member of the Oil Control Board, and responsible for planning oil supplies for the North African campaign.

PERSONAL NOTES

Roger H. Sherman has been appointed co-ordinator of all producing activities of Standard Oil Co. (N.J.) in succession to **John W. Brice,** recently elected to the board. Mr Sherman is succeeded as deputy co-ordinator by **M. A. Wright.**

E. R. L. Fitzpayne, general manager Glasgow Corporation Transport, has been appointed a member of the Oil Consumers' Council in place of **V. Morland**, who resigned on his appointment to the Road Passenger Executive.

REVIEW OF PRESENT STATUS AND TRENDS OF OIL CHEMISTRY*

By GUSTAV EGLOFF†

THE economic and social effects of discoveries in oil chemistry have been far-reaching. The developments are critical in the conservation of petroleum resources. New processes enable the refiner to use every drop of crude oil efficiently, and the industry to meet ever-increasing demands and to adjust operations to changing markets.

Emphasis on research is consistent with the forward-looking attitude of the oil industry, and research in all branches is being constantly expanded. About $112,000,000, 25 per cent of all industrial expenditure for research, are spent yearly by the U.S. oil industry.

GASOLINES

Fuels for internal combustion engines amount to over 50 per cent of all petroleum products, the most important being gasoline. Crude oil averages about 20 per cent gasoline, and with the increasing popularity of the automobile, methods for producing more gasoline from crude oil became imperative. Due to modern development, the present production is about 45 per cent gasoline from every barrel of crude, and there are processes which permit the refiner to produce even more. If it becomes necessary, gasoline production can be increased to over 100 per cent by the hydrogenation of heavy oils.

Cracking more than doubles the yield of gasoline from crude oils. During the 36 years that cracking has been in operation, the increased yield and improved quality of gasoline has made unnecessary the production of 30,000 million barrels of crude oil in the United States alone. The U.S. oil production in 1948 was 2051 million barrels, from which 922 million barrels of gasoline were produced. More than 60 per cent was cracked gasoline. The increased volume and quality of gasoline resulting from cracking processes makes unnecessary the production of an additional 2500 million barrels of petroleum. The greater anti-knock quality and the greater mileage obtained from cracked gasoline saves the motoring public $1000 million yearly in gasoline bills.

The first commercial cracking process was thermal. It has been continuously improved through the years and now processes 2,225,000 barrels of heavy oil daily. About 60 per cent of the U.S. cracked gasoline is thermally produced at present. This gasoline averages about 68 motor octane.

Catalytic cracking produces both higher yields and better quality gasolines, which average 80 motor octane. In only ten years the charging capacity of catalytic cracking plants has increased from zero to 1,500,000 brl/day. In 1940, only 2 per cent of the gasoline produced in the United States was catalytically cracked, but in 1949 over 25 per cent will be thus derived.

Catalytic cracking is extremely important because of its flexibility. For example, gasoline demand is higher in the summer and yield is therefore increased, while heating oil yield is decreased, and the converse is true in the winter.

Re-forming processes have been developed to improve the anti-knock properties of gasoline recovered by primary distillation of crude oil or from natural gas. Heavier portions of these gasolines are re-formed either thermally or with catalysts. About 300,000 barrels of gasoline are thermally re-formed every day. Catalytic processes give higher

* Summary of a paper presented before the U.N. Scientific Conference on the Conservation and Utilization of Resources, Lake Success, N.Y., August 29, 1949.

† Universal Oil Products Co.

yields and better product quality. In the "Hydroforming" process, a molybdenum oxide catalyst is used and hydrogen is mixed with oil vapours to suppress carbon formation. A recently developed process called "Platforming" gives particularly good results. A highly selective platinum catalyst is used. Three simultaneous conversions take place which change low octane hydrocarbons into high octane products. The process yields 90 to 95 per cent gasoline whereas thermal re-forming yields 60 to 75 per cent.

Processes auxiliary to cracking make increased quantities of gasoline still higher in anti-knock rating than the cracked gasoline itself. Both thermal and catalytic cracking produce gases containing olefins. These are catalytically converted into 82 motor octane gasoline by polymerization, which increases the yield of gasoline from cracking by 2 to 10 per cent. By selectively polymerizing butylenes from cracked gases, polymers are obtained which on hydrogenation yield gasoline of over 90 motor octane number.

Alkylation produces gasoline of over 90 motor octane rating by reacting the *iso*butane and olefins from cracked gases. The alkylation products are among the most powerful components of aviation gasoline and, after adding tetraethyl lead, have ratings above 100 on the octane scale.

The search for hydrocarbons of especially high anti-knock properties has led to the production of triptane on a semi-commercial scale. This compound has the highest engine performance rating of any hydrocarbon known and also the highest susceptibility to improvement by tetraethyl lead addition. In specially designed engines the use of triptane has enabled the development of three times the power obtainable from 100 octane gasoline. At present this hydrocarbon can only be produced by costly synthetic processes.

Chemical additives, of which the most important is tetraethyl lead, are another factor in the production of high-quality gasoline. Eighty thousand tons of lead were used in its manufacture in the United States during 1948.

Current trends in automotive and aviation engines are motivating an intensified search for processes to make even higher octane gasolines at lower prices. Compression ratios of present American automobiles are in the range of 6·5 : 1 to 7·5 : 1. Research octane number of U.S. regular gasoline averages 80 research, and premium grade 86 research, while in some localities 93 research octane gasoline is marketed. It is estimated that 30 to 45 per cent of cars on the road require premium gasoline for elimination of knock.

The trend towards higher octane motor fuel is apparent from the experimental engines which have been built. With compression ratios of 8 : 1, 10 : 1, and 12 : 1, gasolines of 93, 98, and 100 research octane, respectively, are required. The 12 : 1 compression ratio engine shows a 35 per cent increase in mileage over that obtained with a 6·5 : 1 engine.

Aeroplanes require even higher qualities of gasoline. The increase in air transportation and the constant improvement of aircraft engines has been a great incentive to the oil industry. Consumption has increased from 70,000 brl/day in 1946 to 128,000 in 1948. The performance ratings of some gasoline blends are as high as 145, compared with 100 octane fuels. The fighting grade fuel is a blend of alkylate and *iso*pentane with an addition of 4·6 ml tetraethyl lead.

Jet Fuels

Jet propulsion of aircraft has created new fuel problems, one of the greatest being high fuel consumption. A jet plane uses five times as much fuel as its reciprocating engine counterpart. A satisfactory fuel must burn rapidly and completely, have very high heating

value per unit weight, and low freezing-point because of the low temperatures at extremely high altitudes.

Kerosine has been and still is used to some extent, but is being replaced by low octane gasoline which is available in larger quantities. The gasoline gives improved performance and facilitates starting in cold weather. Out of the present welter of research will come tailor-made hydrocarbons for jet fuels and new processes for making them, just as special products and processes were found for making high-quality aviation gasolines.

Diesel Fuels

Intensive research is being carried on to develop improved diesel fuels. The use of diesel engines in locomotives is increasing rapidly; 90 per cent of present orders in the United States are for this type of engine. In 1939, consumption of fuel oil by diesel locomotives was 1 million barrels,while in 1949 consumption had risen to 30 million barrels. This shift is an economy measure because the efficiency of diesel engines is over 30 per cent while that of coal- or oil-burning steam locomotives rarely exceeds 5 per cent. The complete replacement of all steam locomotives by diesels would actually lower railroad fuel consumption. The resulting requirements for oil would be only 110 million barrels and coal consumption would be zero. The savings would amount to 40 million barrels of oil and 150 million tons of coal annually.

Heating Oils

Without catalytic cracking, the oil industry could not meet rapidly increasing demands for heating oil. Catalytic cracking, as compared to thermal cracking, produces higher yields of distillate suitable for heating oil and relatively small amounts of residual oil, of which there is over-production at the present time. Production of distillate fuel oils rose over 100 per cent from 1941 to 1948, as compared with 44 per cent for all petroleum products. Inasmuch as oil heating requires less manual labour, is cleaner and more easily regulated than coal heating, it has become popular both for homes and industrial buildings.

Estimates are that oil burners have been installed in over four million American homes.

Liquefied Petroleum Gas

Liquefied petroleum gas, consisting of propane and butane, is one of the most rapidly growing industries in the United States. Sales increased about threefold in the four years from 1944 to 1948, and are now 2600 million gallons per year. At present about 59 per cent is used in industry, 11 per cent in enrichment of city gas, and 19 per cent for chemical manufacture. The industrial figure includes some use as motor fuel for locomotives, buses, and trucks on the west coast of the United States. Demands are being met by augmenting supplies through greater recovery from gases accompanying petroleum production, natural gas, and refinery gas.

Lubricating Oils

Lubricating oils are a $2000 million a year business. Quality of these oils has been constantly improved through the development of chemical processes for their manufacture and through the development of chemical additives. In the U.S., 500,000 pounds of these additives are used daily, some of which are petroleum-based. For example, polymers of ethylene and butylene from cracked gases are used as viscosity stabilizers.

The new lubricants are tailor-made for specialized services varying from the lubrication of fine instruments, such as watches, to use in heavy machinery.

High melting microcrystalline waxes are obtained as by-products of the solvent refining of lubricants. They have a variety of special uses, from

waterproofing leather to furnishing ingredients for ointments and cosmetics.

Synthetic lubricants are of high potential interest. Some of them are being produced commercially, but are at present too costly to warrant extensive use. One class includes members of the silicone group which are synthesized from sand, hydrocarbon oils, and water. They are particularly valuable because their viscosity shows little change between 0° and 200° C. Another type, derived from the cracked gases, ethylene and butylene, also shows excellent viscosity stability. Water-soluble lubricants useful in textile machinery and tyre moulds are derived from ethylene, which is in turn converted to glycol and polymerized.

Chemicals

An entirely new industry has recently come into being as a result of the development of processes for deriving chemicals from petroleum and natural gas. Plants costing over $1000 million are being built in the United States. In 1925 total production was less than 150,000 pounds, whereas in 1948 over 3000 million pounds of raw materials for chemicals were produced. This huge quantity, however, represents less than 0·5 per cent of the annual petroleum production, and has a negligible effect on the supply. It is also estimated that less than 10 per cent of the 5,600,000 million cu. ft. of natural gas produced annually is being used in chemical and carbon black manufacture.

The materials used for chemicals are principally natural gas and gases from petroleum cracking. Utilization of these products for chemicals is a conservation measure as they were formerly burned under boilers and stills. The petrochemical industry is also of economic importance because present chemical demands are much higher than the amount which can be supplied from coal, carbohydrate materials, and fats, formerly the only sources.

Many chemicals can be directly recovered from petroleum and natural gas. Naphthenic acids which are present in some petroleums are useful in making soaps, paint-driers, and fungicides. Cresols, also present in petroleum, are used as disinfectants, in impregnating railway sleepers, and in the manufacture of resins. Nitrogen compounds, mostly of quinoline structure, have potential use, but have not been commercialized.

Natural gas contains recoverable amounts of hydrogen sulphide, carbon dioxide, and helium. The hydrogen sulphide is used for manufacture of elemental sulphur and sulphuric acid. Helium is an inert gas and is used for a variety of purposes in which non-combustibility is an important property. Mixtures of helium and oxygen are supplied to deep-sea divers and caisson workers in place of air. Since helium, in contrast to the nitrogen in air is not adsorbed by the blood-stream, such workers suffer no discomfort during decompression periods.

In manufacturing chemical derivatives from petroleum hydrocarbons, the original materials are usually oxidized, halogenated, sulphonated, or nitrated. Many of the products are used as solvents or intermediates and others are used as finished products.

Many of the oxygenated derivatives are produced on a high tonnage basis. These include alcohols, acids, aldehydes, and ketones. It is of particular interest that petroleum is now a major source of alcohols. Methanol is an excellent example of the shift from coal to petroleum and natural gas for raw materials. Two years ago, over 70 per cent of the United States synthetic methanol production was derived from coal carbonization products. Since then, production has been doubled to over 1000 million pounds and natural gas is furnishing over 70 per cent of the raw material.

The trend is similar for ethyl alcohol. From ethylene, a constituent of cracked petroleum gas, ethyl alcohol is made for

a cost considerably less than alcohol from fermentation of grain. Of the 160 million gallons of ethyl alcohol produced in 1948, 70 per cent was derived from petroleum. If this 112 million gallons of alcohol had been made from corn, it would have involved the use of 1600 square miles of farm land.

Petroleum is the only source of *iso*-propyl alcohol, which is made from propylene, another constituent of cracked gases. Annual production is around 75 million gallons. It is used principally as a de-naturant and a rubbing alcohol. These higher alcohols are now important in the manufacture of plastics and plasticizers formerly obtained only from vegetable oils such as castor oil.

Ethylene glycol is a dialcohol made from the ethylene in cracked gases. The production of this compound in 1948 was 370 million pounds, 70 per cent of which was used as anti-freeze in automobile radiators.

The commercial manufacture of glycerin, a trialcohol, from propylene in cracked gases is the result of years of chemical research. The annual production of this compound in the United States is 35 million pounds. This process has far-reaching significance as a food-conserving measure. Prior to its manufacture from petroleum, all glycerin was made from fats as a by-product of soap manufacture. Fats yield about 10 per cent glycerin, and thus commercial production of glycerin from petroleum will conserve 350 million pounds of fat every year. Reaction of glycerin with acids made by oxidizing petroleum wax yields edible fats which can further contribute to our food supplies. The synthetic glycerin process yields a number of important by-products, including allyl alcohol and acrolein.

Other oxidized products made in large quantities from petroleum and natural gas include formaldehyde, acetaldehyde, acetone, and formic and acetic acids. The oxidation of petroleum wax yields high molecular weight acids which may either be reacted with glycerin to synthesize fats, or used as additives in lubricating oils. By oxidation, ortho-xylene derived from catalytic cracking or hydroforming is converted to phthalic anhydride which finds use in manufacturing plasticizers and alkyd resins. Heretofore, the entire phthalic anhydride production was derived from naphthalene. In 1948 the production from naphthalene was about 150 million pounds, and that from ortho-xylene about 8 million pounds.

Chemicals for Agriculture

Agriculture to-day is highly dependent upon petroleum products. It is one of the largest users of motor fuels, lubricants, heating oils, liquefied petroleum gas, and chemicals. Petroleum companies are devoting great efforts to research on agricultural problems.

The oil industry is producing insecticides, weed killers, fertilizers, and many other products which increase food production. If world food supplies are to be raised substantially, the control of harmful insects, fungus growths, and plant diseases is essential.

Petroleum oils have been used in insecticidal work for a long time. Kerosine and lubricating oils have been employed as carriers for nicotine, pyrethrum, derris, and lead arsenate. More recently, petroleum hydrocarbons have been used in the manufacture of insecticides themselves. Except for chlorine, all of the basic materials for DDT and Gammexane can be obtained from petroleum.

The soil fumigant D-D, a by-product of the synthetic glycerin process, has restored many blighted agricultural areas to productivity by destroying wireworms and nematodes. After soil fumigation, the bodies of the worms become fertilizer. Treatment of infested soil with this petroleum product has increased crop yields over 100 per cent. In southern United States, 3000 square

miles of land can be restored to productivity by the use of this chemical.

Oils and synthetic chemicals from petroleum have been successfully employed as weed killers. Petroleum laboratories are also active in developing plant hormones for stimulating and regulating growth.

About 620,000 tons of ammonia annually is derived from natural gas and liquid air and greatly augments fertilizer supplies. It is now used as fertilizer by direct injection into the soil or irrigation waters, as well as in the form of ammonium nitrate or ammonium sulphate produced through reaction with acid sludges from oil treatment.

Synthetic Rubbers

Pressure of war demands brought about a totally new synthetic rubber industry which produced 1,000,000 tons a year. Synthetic rubbers occupy an assured position because they are produced at a price competitive with natural rubber and because synthetics are better suited to many purposes.

The synthetic rubber produced in greatest tonnage for tyres is GR-S from the copolymerization of butadiene and styrene. Since the inception of synthetic rubber manufacture on a commercial scale in the United States, about 2,000,000 tons of butadiene have been made from petroleum. Recently developed "cold rubber", made at temperatures around 0° C, gives about 30 per cent greater tyre mileage than natural rubber. Because of the superior quality of cold rubber in tyre treads, manufacturing units are being rapidly converted to low temperature operation.

Butyl rubber, derived from petroleum, is a unique product. Inner tubes of butyl rubber maintain air pressure ten times longer than those made of natural rubber. Research is indicating that different types of synthetic rubbers are needed for casings, rims, and treads of tyres so that the future tyre will be a composite of several kinds of rubber.

Resins and Plastics

The resins and plastics industry is one of the largest consumers of chemicals derived from petroleum and natural gas. Ethylene and *iso*butylene are among the basic materials used. The present trend indicates that many of the aromatic-based resins and plastics will be produced from petroleum inasmuch as demand is exceeding the quantities which can be derived from coal sources.

The large variety of resin and plastic products range in physical characteristics from liquids for treating textiles to radio cabinets. They make possible such interesting materials as water-shedding for felt hats and glass that sheds ice and moisture. Special resins, particularly resistant to electrical stresses have been made which are suitable for such uses as radar equipment.

Detergents

Synthetic detergents comprise an industry which is approaching 1000 million pounds annual production. Petroleum is the source of a major portion of the 400 million pounds of active ingredients which are required. Thus the petroleum industry is contributing to fat conservation savings of the order of 1000 million pounds of fat per year, inasmuch as one pound of commercial detergent replaces a quantity of soap which would require one pound of fat for production.

The principal types derived from petroleum are alkyl and aryl sulphonates. Some of the detergents are superior to soap for certain purposes and others have uses in addition to cleansing. In textile finishing they have a wide variety of application.

The new developments in chemicals and their applications are symbolic of the progressive trend of the oil industry. The whole industry stands as a direct outgrowth of research and bases its future on the continued development of new processes and products.

MOTOR INDUSTRY RESEARCH ASSOCIATION

In their report for the year ended June 30, 1949, the Motor Industry Research Association states that in investigating exhaust-valve failure due to high T.E.L. content of fuels, attention has been mainly directed to the type known as "guttering". Using a single-cylinder water-cooled engine, the life of Silchrome 1 valves is inversely proportional to T.E.L. content up to about 4 ml/gal. A report discussing effect of fuel variations and design factors is to be issued.

Fuel Injection

The work on fuel injection being carried out at Queen Mary College has been widened in scope to include compression ignition engines. So far it has primarily been concerned with spray formation, and steps are being taken to correlate spray characteristics with engine behaviour. Reports are being prepared on the effect of liquid properties on flow conditions at the nozzle exit and on the effect of atomization.

C.I. Engine Lubricants

Investigations are being made to establish an engine test, on a "go" or "not go" basis, for C.I. engine lubricating oils. The presence or absence of ring sticking is the criterion, and a 9·6 litre, 6-cyl commercial vehicle engine is being used and results correlated with service tests.

On the basis of 50 hours' maximum the following test conditions have been arrived at: Engine on full load at 1700 r.p.m.; jacket temp., 210° F using 50/50 Glycol-water; oil sump temp., 230° F; ring side clearance, 0·0015 inch.

AGRICULTURAL RESEARCH AT WOODSTOCK

The 169-acre Woodstock, Kent, farm, which the Shell Group purchased in 1945, is now ready to commence operations. It is announced that investigations will cover the agricultural uses of petroleum-based chemicals, the formulation and testing of non-petroleum chemicals used in conjuction with petroleum derivatives, and the examination of other chemicals of interest to agriculture.

The centre will be staffed by a team including entomologists, mycologists, chemists, horticulturists, and engineers. The Group has similar research stations at Modesta, California, and Amsterdam, Holland.

Spraying plum trees at 500 p.s.i. pressure. (A Shell Photograph)

Testing a "Volspray" atomizer machine on a sugar-beet crop. (A Shell Photograph)

THIRD WORLD PETROLEUM CONGRESS

The date and place for the Third World Petroleum Congress has now been fixed for May 28 to June 6, 1951, at The Hague, Holland.

The main headings under which papers will be presented and discussed are:

I. Geology, geophysics, and geochemistry.
II. Drilling and production.
III. Refining technology:
(a) Physico-chemical methods.
(b) Methods involving change in composition.
IV. Petrochemicals.
V. Analysis, testing, measurement, and control.
VI. Utilization of products.
VII. Plant and equipment.
VIII. Transport, storage, and distribution.
IX. Economics and statistics.

The various sessions will be held in hotels in The Hague, and the Information Office will open in the Kurhaus Hotel on May 28, 1951. Excursions to petroleum and industrial centres and to places of interest will be arranged and social events for the evenings will be organized.

The Permanent Council of the World Petroleum Congress, on which Great Britain is represented by Lt.-Col. S. J. M. Auld, O.B.E., M.C., T. Dewhurst, and Hugh C. Tett, has requested the appropriate body in each country to form a national committee which will be responsible for organizing the collection of papers within its own country.

For Great Britain, the Institute of Petroleum has been invited to form the National Committee, and this consists of:

E. A. Evans.
Lt.-Col. S. J. M. Auld, O.B.E., M.C.
C. Chilvers.
T. Dewhurst.
Prof. F. H. Garner, O.B.E.
H. S. Gibson, C.B.E.
H. Hyams.
G. Sell.
C. A. P. Southwell, M.C.
H. C. Tett.

Arrangements are being made to reserve hotel accommodation in The Hague, and further information will be issued from time to time.

Those wishing to receive details and registration forms when these are ready are requested to inform the secretary of the Third World Petroleum Congress, Carel Van Bylandtlaan, 30, Den Haag, Holland.

COMMERCIAL PETROL REGULATIONS

The Motor Spirit Regulations, 1948, name diphenylamine as the ingredient which, when added to any motor spirit, makes it commercial spirit for the purpose of the Motor Spirit (Regulation) Act, 1948.

The Minister of Fuel and Power has now made the Motor Spirit (Amendment) (No. 2) Regulations, 1949 (S.I. 1949, No. 1973) which makes it clear that for the purpose of the Act, the expression "diphenylamine" comprises not only the parent chemical diphenylamine, but also compounds of the same basic structure closely allied to it.

Dust Suppression by Pre-conditioning of Cotton is the title of a booklet recently issued by the Public Relations Department of the M.O.R. Group. It is reprinted from the *Textile Weekly* and is based on a lecture given by H. Paton. Copies are available from 44a Dover Street, London, W.1.

Head Wrightson Processes Ltd. and **The Fluor Corporation** announce the association of their design, engineering, and construction facilities for plants in the petroleum and allied industries.

SASKATCHEWAN OIL SEARCH

An airborne magnetometer survey of 18 million acres of Saskatchewan territory has recently been completed by Aeromagnetic Surveys Ltd. on behalf of the Tidewater Associated Oil Co. Based at Regina and Saskatoon, the aircraft covered 14,000 line miles in less than two months. The magnetic contour maps will be completed by the end of the year.

"100 FACTS IN OIL"

The latest addition to the "Smaller books" is Number 28, which bears the above title. The object of the series is to present a collection of essential facts about a variety of subjects, and the facts in this booklet have been provided by the Petroleum Information Bureau. Published by the Naldrett Press, price is 6*d.*, and copies are available on bookstalls.

Sunvic Controls Ltd. have recently issued leaflets on a D.C. amplifier for use in thermocouple and strain gauge work, and on creep test equipment for use in connexion with metals such as are used in gas turbines.

Mud Pump Selection.—Mud-pump power requirements can now be predicted with greater accuracy, and pump sizes can be selected to give maximum performance as a result of dependable flow-of-slush data. This was the conclusion of H. L. Willke in a paper on "Mud pump selection" recently discussed at the Petroleum Mechanical Engineering Conference of the American Society of Mechanical Engineers. Mr Willke is chief engineer of the National Supply Company, and copies of his paper have been circulated by the company.

A.S.T.M. MEETINGS

A.S.T.M. Committee Week and Spring Meeting is announced for the Hotel William Penn, Pittsburgh, Pa., February 27 to March 3, 1950.

The 53rd Annual Meeting and the Ninth Exhibit of Testing Apparatus and Related Equipment is to take place at the Chalfonte-Haddon Hall, Atlantic City, N.J., June 26–30, 1950.

Standard Hydrocarbons.—Four new standard hydrocarbons have been added to the list of those available from the U.S. National Bureau of Standards. They are $C_{14}H_{30}$, *n*-tetradecane; $C_{15}H_{32}$, *n*-pentadecane; C_7H_{14}, 4, 4-dimethyl-cis-2-pentane; and $C_{10}H_{18}$, *cyclo*pentyl-*cyclo*pentane. Petroleum laboratories should order through the A.P.I., price being $35 per 5-ml unit, payable in advance.

Series operation of mud pumps in Matagorda County, Texas, for two 10,000-ft wells was made possible by two air chambers, 42 inches OD and 90 inches tall. One was between high- and low-pressure pumps to compensate for cyclic volumetric difference between the two pumps. The other was placed in the discharge side of the high-pressure pump to alleviate pressure fluctuations.

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INSTITUTE MEETINGS

The Testing of Liquefied Gases and Light Distillates, of Lubricants, and of Bitumen, and the Measurement and Sampling of Petroleum.—Members of the Standardization Committee. At 26 Portland Place, London, W.1., 5.30 p.m. (*tea* 5 *p.m.*), January 11.

Heysham Refinery—A Study in Adaptability. A. W. W. Kirby. At 26 Portland Place, London, W.1., 5.30 p.m. (*tea* 5 *p.m.*), February 8.

LONDON BRANCH

Annual General Meeting. Motor Racing.—E. A. Evans. At 26 Portland Place, London, W.1., 6 p.m. (*tea* 5.30 *p.m.*, 1*s.*), January 25.

NORTHERN BRANCH

Annual General Meeting. Address by Col. S. J. M. Auld, O.B.E., M.C.—At Engineers' Club, Albert Square, Manchester, 6.30 p.m., January 17.

The Petroleum Industry as a Career.—A symposium by J. Dugdale Bradley, Prof. F. Morton, and Miss C. F. M. McIntosh. At Engineers' Club, Albert Square, Manchester, 6.30 p.m., February 21.

SCOTTISH BRANCH

Motor Racing.—E. A. Evans. At Engineering Centre, Glasgow, 7.30 p.m., February 1.

SOUTH WALES BRANCH

Operational Research.—R. E. Strong. At Britannic House, Llandarcy, 5.30 p.m., January 5.

STANLOW BRANCH

Motor Racing.—E. A. Evans. At Grosvenor Hotel, Chester, 7.15 p.m., January 18.

Annual Dance.—At Quaintways Restaurant, Chester, 8 p.m., January 27.

MEETINGS OF OTHER SOCIETIES

Tanker Design.—N. Carter, N.E. Coast Institution of Engineers and Shipbuilders. At Mining Institute, Newcastle upon Tyne, 6.15 p.m., January 27.

Fuels for Gas Turbines.—C. O. Williams, Institute of Fuel, South Wales Branch. At South Wales Institute of Engineers, Cardiff, 6 p.m., February 3.

Development of the Doxford Oil Engine during the Last Decade.—W. H. Purdie, N.E. Coast Institution of Engineers and Shipbuilders. At Mining Institute, Newcastle upon Tyne, 6.15 p.m., January 13.

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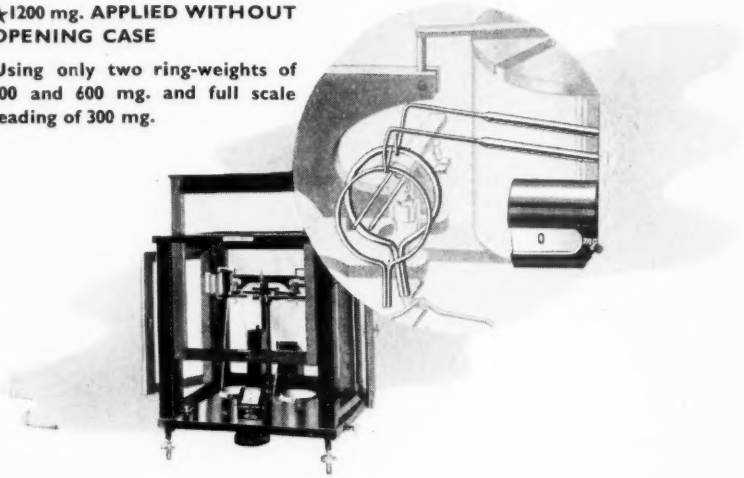

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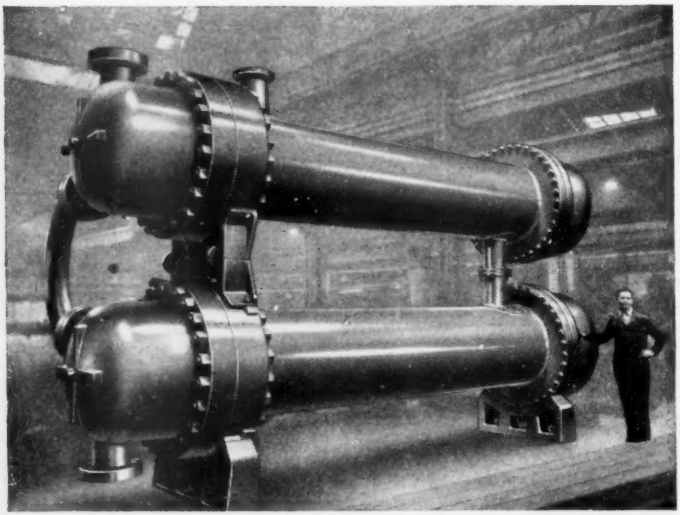

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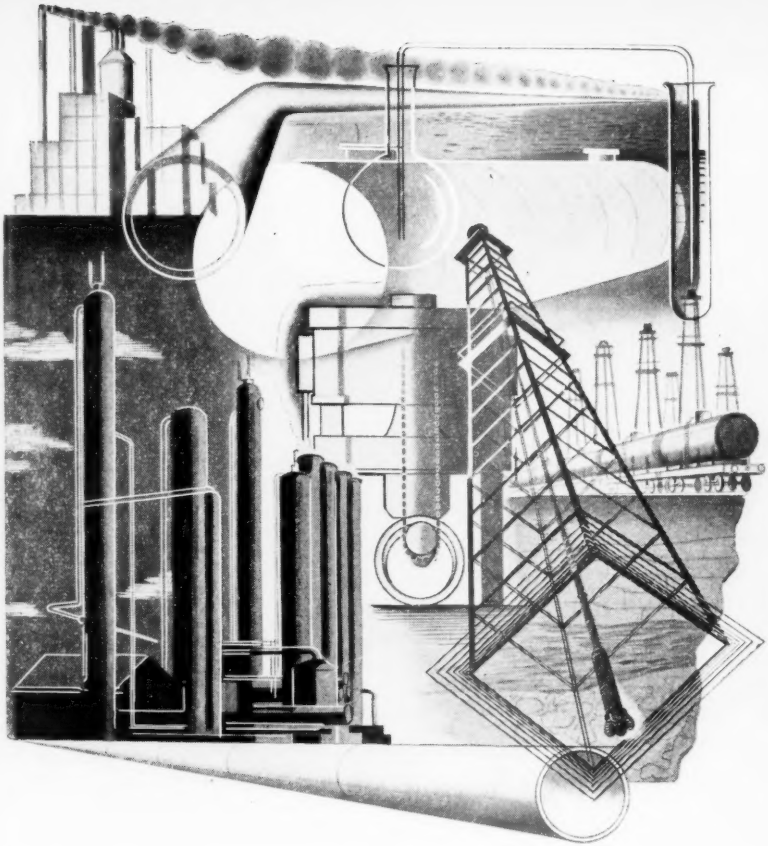

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